

An efficient, water soluble and biocompatible sensor for the detection of PPI and application in cancer diagnosis

Detection of pyrophosphate anion (PPI) has become an important area of research due to its chemical and biological significance especially in early cancer diagnosis. PPI involves in various biological processes (ATP hydrolysis, cellular metabolism, DNA & RNA polymerization and enzymatic reactions) and plays a crucial role for the early cancer detection. Till date, very few sensors for the detection of PPI have been developed in physiological conditions using competitive binding with metal ion, indicator displacement approach and metal–ligand inter-actions based on turn “off–on” or “on–off” sensor. But, the existing technologies for PPI detection have several limitations including lack of selectivity, sensitivity, water solubility, simplicity and high toxicity.

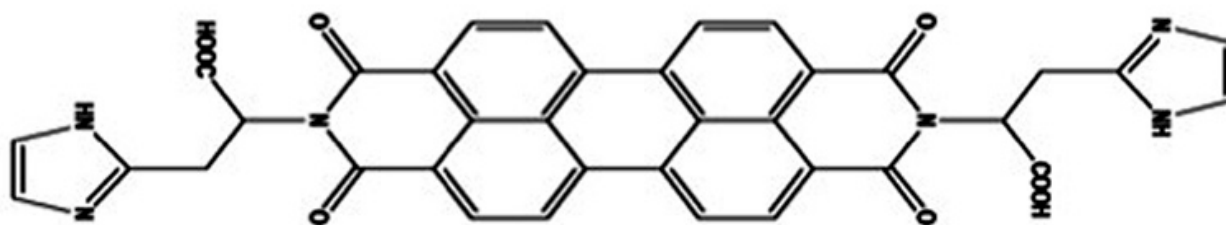


Fig. 1. Chemical structure of PDI-HIS.

In this context, we have designed and developed a highly fluorescent small molecule sensor probe containing a hydrophobic part (perylene diimide) with two hydrophilic tentacles (two amino acid molecules-histidine) (PDI-HIS, see Fig. 1) was designed and developed to be highly water soluble and biocompatible. Further, this biocompatible probe was utilized for the selective recognition of pyrophosphate (PPI) in physiological conditions and *in vitro* live melanoma cancer cells.

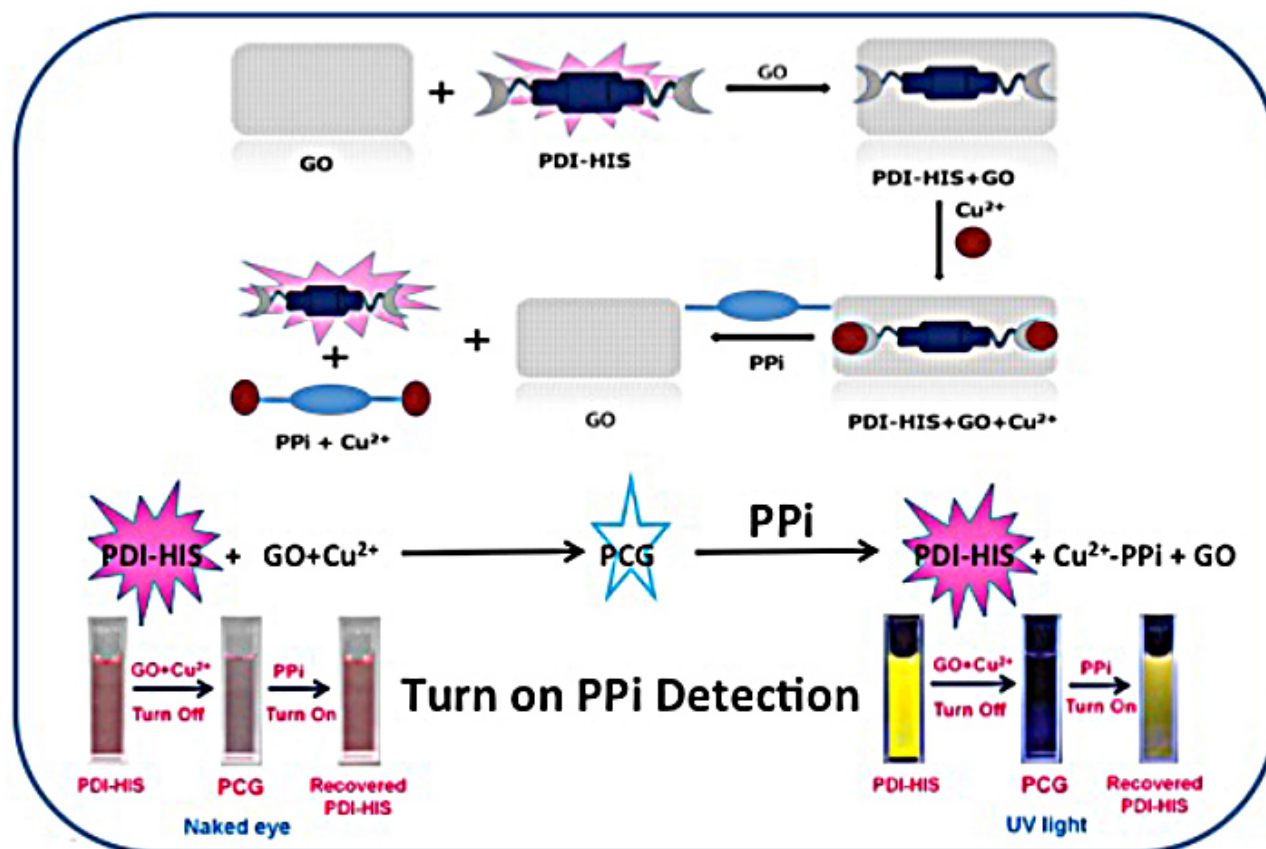


Fig. 2. Schematic representation of highly effective sensing platform in biological conditions and cellular environment via fluorescence “turn-on” for PPI detection using PDI-HIS-Cu²⁺-GO.

The self-assembled nanocomposite probe that comprised of amino acid (histidine) functionalized perylenediimide (PDI-HIS), copper ion and graphene oxide (GO) could be utilized as a highly effective sensing platform in biological conditions and cellular environment via fluorescence “turn-on” for PPI detection (Fig. 2). PDI-HIS showed very bright red fluorescence, which got quenched in presence of copper ion (Cu²⁺) and graphene oxide (GO). Interestingly the red fluorescence of PDI-HIS further reappeared in presence of PPI at very low concentrations in both biological conditions as well as in cellular environment. This controlled fabrication of metal organic self-assembled spheres along with GO proved very valuable for the detection of PPI in unprecedented sensitivity (LOD was found to be 16 ppb) over other competing ions. Thus early cancer detection via PPI recognition in physiological conditions and in live cells was possible using PDI-HIS-Cu²⁺-GO (PCG).

Furthermore, we used portable PVA hydrogel films and thin layer chromatography plates to demonstrate the practical utility for the detection of PPI anions by “off-on” response rapidly in a label free manner. Thus this PDI-HIS molecule is highly versatile with applications in chemical and

biological sensor including detection of cancer biomarkers and its fabrication as a handy and portable sensor that could be distinguished by a color change observed via naked eye or under a hand-held UV lamp or torch.

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Publication

[An efficient strategy to assemble water soluble histidine-peryene diimide and graphene oxide for the detection of PPI in physiological conditions and in vitro.](#)

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Biosens Bioelectron. 2015 Dec 15